WOULD REDUCING CARBON DIOXIDE EMISSIONS IN THE UNITED STATES SERIOUSLY HARM ITS ECONOMY?

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Introduction

Kyoto Protocol, a maiden step taken by the international community towards slowing down global warming induced climate change, requires economically developed countries to reduce their greenhouse gas (GHG) emissions from 1990 levels by specified amounts during the period 2008 to 2012. United States (US), despite its initial support to the Protocol, has declined to ratify it. It would be of interest to research why US, despite having the economical means and the knowledge base to invest on alternatives to emissions intensive technologies, should abandon the Protocol. The focus of this study was to investigate the type and degree of dependence between US carbon dioxide emissions (CO_2), the major GHG emissions, and its economy, proxied by gross domestic product (GDP). In particular, I researched for the existence of possible long-run and short-run equilibrium relationships between CO_2 and GDP, employing the cointegration testing methodologies.

Data Analyses

Figure 1 shows CO_2 emissions stemming from fossil-fuel burning, cement manufacture and gas flaring (Marland *et al.*, 2009), versus GDP (Bureau of Economic Analysis, 2009) for the period 1950 to 2005. Figure 2 shows the annual average crude oil prices (British Petroleum, 2009) for the same period.

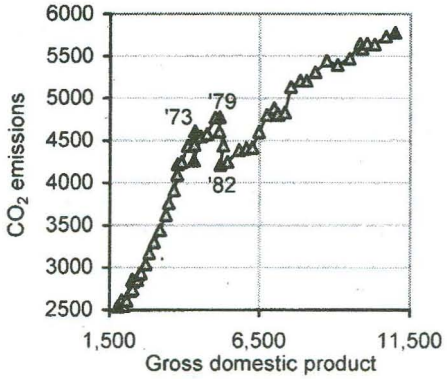

Figure 1. CO_2 emissions (in Mega tonnes CO_2) versus GDP (in billions of constant 2000 US$) of US during 1950 to 2005.

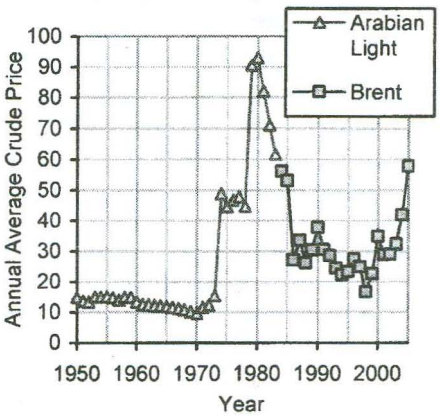

Figure 2. Variation in the crude oil price (in constant 2007 US$ per barrel).

Figure 1 shows that CO_2 in US has been increasing with increasing GDP since 1950 except for the sharp decline first in 1973 and then in 1979, both are oil price peak years (Figure 2). It is also of interest to observe the notable decreases in CO_2, during 1973-75 and 1979-82, were accompanied by no appreciable GDP growths. Another

notable feature is the rate of increase of CO_2 with GDP since 1982, which is much lower than that till 1973. It is therefore evident that statistical modeling of the CO_2-GDP relationship requires the use of an independent variable that could account for the aforementioned local peak-and-valley structure and varying slopes, as done in this research using the oil price.

Model Development

For model development, natural logarithms of CO_2 emissions, GDP and oil price, denoted respectively by C, G and O, are used. Autoregressive distributed lag (ARDL) bound-testing approach to cointegration (Pesaran *et al.*, 2001) is used to investigate into the probable existence of cointegrating relationship among C and G and O. The procedure used was similar to that reported in Shanthini (2009), except for the inclusion of a restricted trend term in the equilibrium correction model (ECM) for C. The F-statistic under the null of no cointegration and the t-ratio under the null of zero coefficient of the $C(t-1)$ term in ECM, with up to six lags of first-differenced variables, were 6.66 and -3.97, respectively. The F-statistic is found to lie above the upper bound critical value and the t-ratio to lie outside the upper bound critical value, both at 5% level of significance. The existence of cointegration among C and G and O is therefore established.

As the next step, the following long-run equilibrium relationship is established using the ARDL approach:

$$C(t) = \underset{[5.9]}{2.836}G(t) - \underset{[-1.9]}{0.080}O(t) - \underset{[-5.0]}{0.077}(t-1950) - \underset{[-3.7]}{13.185} + \hat{v}(t) \quad (1)$$

The corresponding short-run equilibrium relationship is as follows:

$$\Delta C(t) = \underset{[-5.4]}{-0.175}\hat{v}(t-1) + \underset{[10.0]}{1.076}\Delta G(t) - \underset{[-3.2]}{0.369}\Delta G(t-2) - \underset{[-3.5]}{0.019} + \varepsilon(t) \quad (2)$$

with has an adjusted R^2 of 72.5% and Durbin-Watson statistic of 2.28. The t-statistics corresponding to the coefficients are given in the brackets below the corresponding coefficients. Eq. (1) gives the equilibrium correction term, $\hat{v}(t-1)$ of Eq. (2).

Discussion

The adjustment parameter of $\hat{v}(t-1)$, which has the desired negative sign and is highly significant, reveals that a deviation from the long-run equilibrium is corrected by 17.5% in a year. The short-run dynamics are such that, even though there exists a strong one to one relationship between the current growths in CO_2 and GDP, the past GDP growth has a reducing effect on current CO_2 emissions. Eq. (1) reveals that 1% increase in GDP leads to about 2.8% increase in CO_2 emissions in the long run, whereas 1% increase in the oil price leads to 0.08% decrease in CO_2 emissions. The statistically significant, small negative coefficient of the linear trend term in Eq. (1) signifies the tendency of CO_2 emissions growth to gradually reduce with time.

Using the model developed in this study, CO_2 emissions for US was forecasted beyond 2005 assuming 2% growth rate in oil price and r % growth rate in GDP since 2005, where r was taken as 1.5, 2.0, 2.5, 3.0 and 3.5. The results tabulated in Table 1 shows the model predicted percentage changes in CO_2 emissions over the 1990 level for

different hypothetical scenarios assumed. Since the model stipulates that the GDP growth causes CO_2 emissions in US to rise at a faster rate than the rate at which the emissions decline owing to increasing oil price, CO_2 emissions in US continue to grow until 2012 even at a GDP growth rate as low as 1.5%, as tabulated in Table 1, thereby defying its expected Kyoto Protocol target, which was 7% below 1990 level to be achieved during 2008-12. Table 1 also reveals that no appreciable emissions reduction could be experienced in US for GDP growth rates exceeding 2.5% even with oil price increasing at a rate of 2%.

Conclusion

The model is able to capture the gradually reducing tendency of CO_2 emissions with time, owing, perhaps, to factors such as technological progress. Nevertheless, the model developed shows that no appreciable CO_2 emissions reduction is possible for GDP growth rates exceeding 2.5% even with oil price growing at a low 2% rate. The defied Kyoto protocol target could therefore not be achieved by US without severely compromising its GDP growth. However, the analyses carried out in this study reveals that the CO_2 emissions and the GDP of US are tied to each other on a long-run equilibrium relationship only through the oil price. In other words, it is the oil dependence of US that results in the prevailing state of affair that causes 'economic development at the expense of ecological degradation'. In the case concerned here the environmental degradation is the irreversible global warming and the resulting climate change.

Acknowledgement

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Table 1. Predicted percentage changes in carbon dioxide emissions of United States over the 1990 level assuming 2% growth in oil price and *r*% growth in GDP since 2005

Year	$r = 1.5$	$r = 2.0$	$r = 2.5$	$r = 3.0$	$r = 3.5$
2012	0.6%	6.3%	12.2%	18.5%	25.0%
2020	-22.8%	-10.1%	4.7%	21.8%	41.6%
2030	-46.2%	-28.2%	-4.3%	27.5%	69.5%